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Research Report
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Marketing Fresh Tomatoes

Systems and Costs

Robert C. Mongelli

VF - TOMATOES

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Preface

This study is part of a continuing research program designed to find more efficient and less costly systems for handling agricultural products from producer to consumer. This program, conducted by USDA's Agricultural Marketing Service, also is designed to determine which system or systems best maintain the quality of the food product.

Appreciation is expressed to all growers, packers, shippers, carriers, and receivers of fresh tomatoes who made their facilities available and permitted researchers to measure and evaluate the various systems. Thanks also is extended to individuals in government and academic institutions who aided in this research.

Single free copies of this publication may be obtained while supply lasts from the Market Research and Development Division, Agricultural Marketing Service, USDA, Washington, D.C. 20250.

February 1984

For sale by the Superintendent of Documents, U.S. Government Printing Office
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Marketing Fresh Tomatoes

Systems and Costs

By Robert C. Mongelli[1]

Methods for harvesting and handling mature green fresh tomatoes from growing area to retail store were studied to provide an overview of the total marketing system and to determine the relative costs of different methods within the marketing system.

At harvest point, three methods of handling tomatoes were studied, utilizing bins, wooden field boxes, and fiberboard field boxes. When 800-pound-capacity wooden bins were used to transport tomatoes from the field to the packing plant, total labor, equipment, and material cost was $24.08 per ton. When 50-pound-capacity wooden field boxes were used, cost per ton totaled $30.37, while use of 30-pound-capacity fiberboard boxes had a cost per ton of $35.34. Although the use of 800-pound-capacity bins resulted in the lowest cost per ton, little research has been conducted to compare the damage rate of these bins with that of the 30- or 50-pound-capacity boxes.

Packing plant costs were approximately $2.26 per 30-pound carton. This cost is based on a budget developed for central California for mature green tomatoes shipped during the late summer and fall.[2]

Transportation represents the largest cost factor in the fresh tomato marketing system. Loading and unloading functions and shipping platforms (pallets and slipsheets) also add costs. Four methods of transporting fresh tomatoes from packing plant to wholesale receivers were studied: handstacked loading and unloading, slipsheet, pallet pool, and pallets. The handstacked transportation method had the lowest labor, equipment, material, and transport charges, $1.0362 per carton. Costs per carton for the other methods were: slipsheet $1.0403, pallet pool $1.0645, and palletized $1.1112.

Tomato repacking costs ranged from $36.60 per 1,000 pounds for 10-million-pound capacity handled to $46.70 per 1,000 pounds for 1.5-million-pound capacity. These costs include labor and equipment to sort, pack, and handle within the repacking facility.

[1]Marketing specialist, Market Research and Development Division, Agricultural Marketing Service, Washington, D.C. 20250.

[2]Zepp, G.A. and Simmons, R.L. Producing Fresh Tomatoes in California and Baja, California. ESCS-78, February 1980.

Introduction

Three methods of wholesale warehouse handling and delivery were studied: palletized delivery, mobile cart delivery, and handstacked delivery. The palletized delivery method had the lowest labor, equipment and material cost per carton, $0.2510. The mobile cart delivery method and handstacked delivery method had a cost per carton of $0.2616 and $0.2948, respectively. Only one method was studied for handling tomatoes at the retail store and the cost per carton was $0.2340.

When methods can be interchanged, the most cost efficient combination would be one that uses the bulk bins for handling tomatoes from field to packing plant and handstacking transport from packing plant to wholesale warehouse. From the wholesale warehouse to the retail store, palletized delivery would be the most cost efficient method. The combination of these methods would give the most cost efficient system.

The tomato is grown throughout the United States and in most moderate temperature regions of the world. It is a warm-season plant reasonably resistant to heat and drought, and grows under a wide range of climate and soil conditions. It requires 3 to 4 months from the time of seeding to produce the first ripe fruit. The tomato thrives best when the weather is clear and rather dry, and temperatures are uniformly moderate 65° F. to 85° F.

Plants usually freeze at temperatures below 32° F., and they do not increase in size at temperatures above 95° F. High temperatures accompanied by high humidity favor the development of foliage disease. Quality is strongly influenced by temperature. Hot drying winds cause the flowers to drop. Varieties with pistils shorter than the staminal cone have less blossom drop than others. Irrigation will lower the temperature, raise the humidity, and prevent much of the blossom drop.[3]

Fresh tomatoes, produced commercially in 26 States, are available year-round. The leading producing States are Florida, California, and South Carolina. U.S. per capita consumption is approximately 12 pounds.[4] In the United States the tomato is a leading fresh market vegetable with an average (1979) annual production of over 2 billion pounds valued at $517 million.[5] Tomato varieties include cherry, round, and pear-shaped in various shades of red or yellow. Those most commonly found in retail stores are pink or light red, round, and average about 3 inches in diameter.

Most fresh tomatoes are moved from producing areas to final destination by truck. Figure 1 shows the fresh tomato marketing system from shipping point to consumer.

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[3]Tomatoes, Fruit and Vegetable Facts and Pointers, United Fresh Fruit and Vegetable Association. December 1969.

[4]What Causes Food Prices to Rise? What Can Be Done About It? GAO, CED-78-170. Sept. 8, 1978.

[5]Agricultural Statistics. 1980. USDA.

Objective and Methodology

The purpose of this report is to show the marketing system for mature green fresh tomatoes from grower to retail store and the relative costs for the major handling methods within the system. Caution should be used in applying the costs for these methods to get a total cost figure for the movement of fresh tomatoes from grower to retailer. These costs were gathered in different parts of the country and at different times of the year. Therefore, the costs shown are those developed at the particular fields and facilities studied; use of the same methods at different fields and facilities may give slightly different results. Cost data for methods within a phase of the marketing system, where these methods are interchangeable, could be used to compare the cost of one method with another.

For manual harvesting and handling three methods were evaluated, using fiberboard boxes, wooden field boxes, and bins. Costs were measured for labor, equipment, and materials in worker-hours, equipment-hours, and dollars per functions performed. The equipment-hour requirements were converted to costs by using hourly ownership and operating costs.

To measure the harvesting and handling operations with consistency, it was necessary to develop a breakpoint between harvesting and packing operations. For purposes of this study, harvesting included all handling including unloading the tomatoes from the field truck at the packing plant. For each harvesting and handling method, a model was constructed that included a typical size load, labor, equipment, material requirements, and costs. Data for this part of the study were obtained in southern Florida and Rio Grande Valley in Texas.[6]

The packing plant operation began when the tomatoes entered the packing plant after unloading from the field. It ended when the tomatoes were placed in temporary holding areas after packing and before being moved to the over-the-road transport vehicle for loading. The carton used in this part of the study was the 30-pound-capacity fiberboard carton.

The transportation methods from packing plant to wholesale warehouse consisted of loading, transporting, and unloading. Loading started when the fresh tomatoes were taken from the end of the packing line or storage and moved into the transport vehicle. Loading was completed when the last carton was securely in place in the transport vehicle, the dock plate removed, and the trailer doors closed. For transportation four loading methods were evaluated: handstacked, palletized, pallet-pool, and slipsheet. A refrigerated highway trailer, 40 feet long, was the transport vehicle. Costs were based on 900 30-pound cartons per trailer load. Over-the-road transportation started when the transport vehicle left the loading area at origin and ended at the wholesale warehouse.

To facilitate comparison of over-the-road shipping costs, only one shipping point (Miami, Fla.) and one receiving point (Washington, D.C.) were used. To determine the least costly method, various packing plants, wholesale warehouses, and retail stores were selected for detailed analysis.

Unloading at the wholesale warehouse started when the trailer doors were opened and the dock plate positioned; it was completed when the last carton was in place in the warehouse storage area. The data for this part of the study were collected in southern Florida and the Washington, D.C., metropolitan area.[7]

The handling methods from wholesale warehouse to retail store consisted of order assembly, stock replenishment, loading, transportation, and unloading at the retail store. Order assembly began when the first carton was selected as part of a full trailer load. Assembly ended when the last carton was selected. Loading, transportation, and unloading had the same parameters as the loading, transportation, and unloading used for over-the-road transportation. The three studied were: handstacked delivery, palletized delivery, and mobile cart delivery.

The handling method for retail store operations consisted of movement of fresh tomatoes from storage to display case, display case loading, and removal of empty cartons.

Repacking may occur between the shipping point at origin and the terminal markets (fig.1). Some retail groups have their own ripening and repacking facilities.

The worker-hour labor requirements were converted to costs using the prevailing usage rates for the job categories as reported by the cooperating packing plants,

[6]Mongelli, Robert C., Anthony, Joseph P. and Volz, Marvin D. Evaluating Two Systems of Harvesting and Handling Fresh Tomatoes. ARS-NE-94. 1978.

[7]Mongelli, Robert C. A Comparison of Handling Systems for Fresh Tomatoes From Packing Plant to Retail Store. MRR-1111. July 1980.

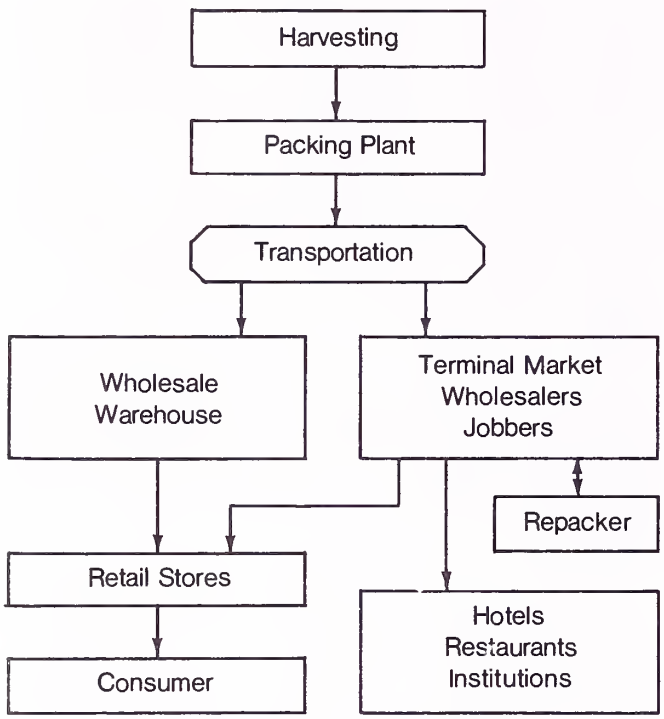


Figure 1.—Fresh tomatoes from shipping point to consumers. (Modified from How Fresh Tomatoes Are Marketed. See footnote 9, page 6 .)

wholesale warehouses, and retail stores. A 15-percent personal fatigue allowance was added to all labor requirements to provide a standard time for performing the various operations. The equipment-hour requirements were converted to costs using hourly ownership and operating costs (see table 19, page 27).

Since most fresh tomatoes are either harvested as vine ripe or mature green and different handling methods are used in the field and the packing plant for each type, it was necessary to determine the type (vine ripe or mature green) that should be studied for this report. Mature greens were selected for the study because they constitute 80 percent[8] of commercial tomato harvest. From the end of the packing line to the retail store both types are handled approximately the same way and the results for the mature green can apply to the vine ripe.

[8]Worthington, John T., Anthony, Joseph P., and Mongelli, Robert C. Today's Fresh Tomato Marketing System and a Perspective of a System for The Future. ARM-NE-2. October 1978.

Harvesting

Nearly all fresh tomato harvesting is done manually. But during the past few years developmental work on mechanical harvesting of tomatoes for the fresh market has been progressing.

Manual

Most commercially grown fresh tomatoes are harvested as either "mature green" or "breakers." A mature green tomato has a completely green skin but has reached the stage where the skin will turn red either on or off the vine. A breaker tomato, in its first stage of changing color, is primarily green with a tinge of yellow or pink, usually at the blossom end. Breakers are commonly termed "vine ripe" in the tomato industry. Mature green tomatoes and breakers are firm enough to withstand handling during the marketing process and the time and travel necessary to get to market. Once mature greens or breakers are fully red, it is impossible to tell at which stage the tomatoes were harvested.

When tomatoes are harvested mature green, a field usually is picked two or more times at 4- to 10-day intervals, depending on weather and market conditions. While most are mature green, some have reached the breaker stage. The tomatoes are usually transported to the packing plant in field boxes holding up to 70 pounds, or bins holding 800-1,200 pounds.

When harvested as vine ripe, tomatoes are picked daily or every 2 days. Frequent harvest is necessary to avoid tomatoes that are soft and that cannot be shipped to distant markets without heavy losses. Vine ripe tomatoes typically move in field boxes to packing plants.[9]

The harvesting and handling operations in the field for mature greens were the same for the three methods studied. A picker, equipped with a canvas bucket, harvested the tomatoes by walking through the rows picking those ready for harvest (fig. 2). After the bucket was filled, the picker walked to the end of the row, emptied the bucket's contents into the boxes stacked for filling, and then returned to the field. The walking distance may be from a few yards to as much as 100 yards.

[9]Fahey, James V. How Fresh Tomatoes are Marketed. U.S. Dept. Agr., Mktg. Bul. No. 59, October 1976.

Figure 2.—Manual harvesting of fresh tomatoes.

The differences in operation began when the tomatoes in the canvas bucket were emptied into either a fiberboard box (method 1), a wooden box (method 2) or a bulk bin (method 3).

In method 1 a fiberboard box with a 30-pound capacity and estimated use life of four trips was used for transporting fruit to the packing plant. Outside dimensions of the box were approximately 18 by 12 by 9 inches and it weighed approximately 2.4 pounds. The packing plant purchased these fiberboard boxes with overhanging tops from various produce wholesalers. The filled boxes were hand-loaded onto a truck for transporting to the packing plant. After arrival the boxes were placed on a roller conveyor that led into the plant.

In method 2 a 50-pound-capacity wooden box with estimated life of 200 trips was used. Outside dimensions of the box were approximately 22 by 14 by 8 inches and it weighed about 15 pounds. The filled boxes were hand-loaded onto a truck for transporting to the packing plant. After arrival, boxes were unloaded and moved into the plant with use of two-wheeled handtrucks.

In method 3 an 800-pound-capacity wooden pallet bin was used. Estimated bin life was 250 trips. Outside dimensions were approximately 45 by 45 by 29 inches. The bin weighed 130 pounds. The filled bins were loaded onto a flatbed truck using a tractor with a forklift attachment for transportation to the packing plant. After arrival forklift trucks unloaded the bins and moved them into the plant.

One tomato picker required 4.76 worker-minutes to pick tomatoes and fill a bucket, 0.53 worker-minute to transport the filled bucket to a fiberboard box or a wooden field box or bin and empty it, and 0.49 worker-minute to return to the field and resume picking. Total time was 5.78 worker-minutes per bucket. Because of the difficulty of the work a 20-percent fatigue allowance was used. The total labor requirement per bucket was 6.94 worker-minutes.

In method 1, one bucket filled about 1.67 fiberboard boxes, with 550 boxes (16,500 pounds) constituting a truckload. By using a crew of 20 pickers, this yields a labor requirement of 38.17 worker-hours per truckload for harvesting (1 picker = 6.94 worker minutes X 330 filled buckets ÷ 60 minutes = 38.17 worker-hours).

When the fiberboard boxes were filled for a truckload, the workers carried the boxes to a flatbed truck (with sides) for loading. Two workers on the ground lifted the boxes onto the truck and two workers on the truck stacked the boxes. Loading the truck required a total of 3.38 worker-hours.

The loaded truck was driven from the field to the packing plant, which required a travel distance of less than a mile to 5 miles. At the packing plant two workers on the truck transferred filled tomato boxes to two workers on the ground who dumped the tomatoes into a trough. As the truck was unloaded, a roller conveyor was set up in the truck to help facilitate unloading.

The four-worker crew required 3.78 worker-hours and 0.93 equipment-hour to unload 550 filled boxes from the truck. Two workers reloaded the field truck with empty boxes, requiring a total of 2.09 worker-hours.

Elapsed travel time from field to plant totaled 0.18 hour based on 2 to 3 miles of travel, 0.94 hour to unload filled boxes, 1.04 hours to load empty boxes, and 0.18 hour to return to the field, a total of 2.34 worker-hours.

With this method, the equipment used was a flatbed truck (with sides), 20 picking canvas buckets, and 550 fiberboard boxes for a total of 5.098 equipment hours.

In method 2 one full bucket filled one wooden field box. Three hundred field boxes (15,000 pounds) constituted one truckload. By using a crew of 10 pickers, this yields a labor requirement of 34.70 worker-hours per truckload for harvesting (1 picker = 6.94 worker-minutes X 300 filled buckets ÷ 60 minutes = 34.70 worker-hours).

When the wooden field boxes were filled for a truckload, the workers carried the boxes to a flatbed truck (without sides) for loading. Two workers on the ground lifted the boxes onto the truck and two workers on the truck stacked the boxes. Loading the truck required a total of 2.23 worker-hours.

To facilitate unloading at the packing plant, a worker on the truck separated a column of boxes with a crowbar. A second worker on the truck clamped onto the column of boxes with a clamping two-wheel handtruck, and transported the load approximately 45 feet from the truck to the conveyor line in the plant. The total time to unload the truck was 1.39 worker-hours and 0.86 equipment-hour.

A two-worker crew reloaded the truck with empty wooden field-boxes. The first worker transported the boxes with a two-wheel handtruck to the second worker on the truck who stacked the boxes. The total time to reload the truck with 300 empty wooden field boxes was 2.40 worker-hours and 1.10 equipment-hours.

The trip for the truck to the packing plant required 0.18 hour, 0.69 hour to unload filled boxes, 1.20 hours to load empty boxes, and 0.18 hour to return the empty boxes to the field or 2.25 worker-hours.

With this method the equipment used was a flatbed truck (without sides) 10 picking canvas buckets, and 300 wooden field boxes for a total of 6.282 equipment hours.

In method 3 it took 16 buckets to fill an 800-pound-capacity bin. A full truckload consisted of 20 bins for a total truckload of 16,000 pounds. By using a crew of 20 pickers, this yields a labor requirement of 37.01 worker-hours per truckload for harvesting (1 picker = 6.94 worker-minutes X 320 filled buckets ÷ 60 minutes = 37.0133 worker-hours).

When the bins were filled for a truckload, a tractor equipped with a forklift was used to place the filled bins on a flatbed truck. A crew of two (a forklift driver and a helper) loaded the truck. Loading the truck required a total of 0.40 worker-hour and 0.20 equipment-hour.

At the packing plant two forklift trucks were used to unload. Full pallet bins were moved two at a time and transported into the packing plant. Each forklift truck made five trips for a total time of 1861 worker- and equipment-hour for the two forklift trucks and operators. The field truck was reloaded by the same forklift trucks with 20 empty bins and required 0.1700 worker- and-equipment hours.[10]

[10]Data obtained from Anthony, Joseph P., Mongelli, Robert C., and Volz, Marvin D. An evaluation of system for harvesting grapefruit in Texas. ARS-NE-57. April 1975.

The trip for the truck from the field to the packing plant required 0.18 hour, 0.09 hour to unload filled bins, 0.08 hour to load empty bins, and 0.18 hour to return to the field or 0.53 worker-hour.

With this method, the equipment used was a flatbed truck, 20 picking canvas buckets, 20 pallet bins, and three forklift trucks for a total of 2.58 equipment-hours.

The bin capacity use in this model is only one of many capacities now in use. Bulk bins holding 800-1,200 pounds have become widespread in Florida and California.[11] [12]

Table 1 shows the hourly ownership and operating costs for equipment required for the three methods of harvesting.

Table 2 shows the initial box and bin costs and the cost per trip for the three harvesting methods. Costs per load were $4.00, $10.50 and $41.25 for the pallet bins, wooden field boxes, and fiberboard boxes, respectively.

Table 3 shows labor, equipment and cost per ton for the three methods. The least cost method was the pallet bin method ($24.08 per ton) followed by the wooden box method ($30.37 per ton) and the fiberboard box method ($35.34 per ton).

Table 1.—Hourly ownership and operating costs for equipment required for three methods of harvesting and handling fresh tomatoes

Method and equipment	Initial cost[1]	Total fixed costs[1]	Variable costs		Total variable costs	Total fixed and variable costs	Costs per hour of operation[2]
			Power	Maintenance			
				Dollars			
Method 1 (fiberboard boxes):							
Flatbed truck with sides .	12,000.00 (6)	3,800.00	[3]900.00	[4]1,200.00	2,100.00	5,900.00	1.383
Harvesting bucket	6.50 (4)	2.59	—	—	—	2.59	.012
Roller conveyor	100.00 (7)	29.28	—	[5] 1.50	1.50	30.78	.007
Method 2 (wooden field boxes):							
Flatbed truck	11,500.00 (6)	3.641.66	[3]900.00	[4]1,150.00	2,050.00	5,691.66	1.344
Harvesting bucket	6.50 (4)	2.59	—	—	—	2.59	.012
Handtruck.....	80.00 (10)	20.00	—	[5] 1.20	1.20	21.20	.005
Method 3 (pallet bins):							
Flatbed truck	11,500.00 (6)	3,641.66	[3]900.00	[4]1,150.00	2,050.00	5,641.17	1.334
Harvesting bucket	6.50 (4)	2.59	—	—	—	2.59	.012
Field forklift tractor	14,000.00 (8)	3,850.00	[3]450.00	[5] 210.00	660.00	4,510.00	1.057
Forklift truck.....	11,000.00 (8)	3,025.00	[3]450.00	[5] 165.00	615.00	2,640.00	.853

[1]Total fixed costs include straight line depreciation (estimated life in years in parentheses after initial cost), interest at 10 percent of initial cost of 20 percent of depreciated balance, and insurance and taxes at 5 percent of initial cost.

[2]Based on total of 1,600 hours of annual operation for all equipment multiplied by 0.375 or 600 hours (3 months) equipment used for tomato operation. Harvesting buckets used 200 hours per month.

[3]Fuel costs calculated at $300 per month for 3 months for trucks and $150 per month for forklift trucks.

[4]Maintenance costs at 10 percent of initial cost.

[5]Maintenane at 1.5 percent of initial cost.

[11]See footnote 9, page 6.

[12]Jesse, Edward V. Packing California Mature Green Tomatoes, Cost and Efficiencies. U.S. Dept. of Agr., Economic Research Service, AER No. 282, February 1975.

Table 2.—Box or bin cost and total cost per load

Type	Boxes or bins needed per trip	Initial cost per box or bin	Trips per useful life	Cost per box or bin	Cost per load
	Number	*Dollars*	*Number*	*Dollars*	*Dollars*
Fiberboard box	550	0.30	4	0.0750	41.25
Wooden box	300	7.00	200	0.0350	10.50
Pallet bin	20	50.00	250	.2000	4.00

Table 3.—Plant labor and equipment costs for harvesting and transporting fresh tomatoes from field to packing plant with three methods[1]

Item	Method 1 (fiberboard boxes, 16,500 pounds per truckload)	Method 2 (wooden boxes, 15,000 pounds per truckload)	Method 3 (pallet bins, 16,000 pounds per truckload)
	Dollars	*Dollars*	*Dollars*
Labor cost:			
Harvesting[2]	181.31	164.82	175.80
Truck loading in field[2]	16.05	10.59	2.00
Transportation[2,3]	15.90	14.05	4.65
Packing plant[2]	29.35	18.95	1.80
Harvesting and plant equipment cost:			
Truck	[4] 7.05	[5] 8.38	[6] 3.44
Harvesting buckets	[4] .66	[5] .48	[6] .50
Fiberboard boxes (550)	[7] 41.25	—	—
Wooden field boxes (300)	—	[7] 10.50	—
Pallet bins (20)	—	—	[7] 4.00
Roller conveyor	[8] .01	—	—
Hand truck	—	[9] .01	—
Forklift trucks	—	—	[10] .48
Total labor and equipment cost:			
Per load	291.58	227.78	192.67
Per ton	35.34	30.37	24.08

[1]Harvesting data for methods 1 and 2 revised and updated from Mongelli, Robert C., Anthony, Joseph P. and Volz, Marvin D. Evaluating Two Systems of Harvesting and Handling Fresh Tomatoes. ARS-NE-94. 1978.

[2]Wage rage for field workers at $4.75 per hour and for truck drivers, forklift truck drivers, and plant workers at $5.00 per hour.

[3]Costs include time to load truck, drive to packing plant, unload, reload empty boxes, and drive to field.

[4]Equipment-hours per truckload were 5.098 for the truck and 55.07 for the harvesting buckets (hourly ownership and operating costs developed in table 1).

[5]Equipment-hours per truckload were 6.282 for the truck and 40.27 for the harvesting buckets (hourly ownership and operating costs developed in table 1).

[6]Equipment-hours per truckload were 2.581 for the truck and 41.74 for the harvesting buckets.

[7]Box cost developed in table 2.

[8]Equipment-hour requirement per truckload was 0.93.

[9]Equipment-hour requirement per truckload was 2.06.

[10]Equipment-hour requirement per truckload was 0.56.

Mechanical

Up to 1968, mechanical harvesting equipment did not exist that was designed specifically for fresh tomatoes. Experimental harvesting equipment for fresh tomatoes is now being tested.

There are major problem areas to overcome before mechanical harvesting comes into regular commercial practice. Studer and Chen reported, ". . . That the principal impediment to commercial acceptance of machine harvesting for mature green tomatoes is the lack of acceptable fruit varieties which are easily detached without stems. The presence of stems results in puncture injury, and a large crew size is required for destemming the fruit.[13]

Another problem to overcome is the rough handling that the fresh tomato encounters as it is being harvested mechanically. Work on solving these problems is continuous. Sims et al discuss requirements for mechanically harvesting fresh market tomatoes.[14]

Commercial mechanical harvesting of fresh tomatoes on a large scale is still in the future, but mechanization is inevitable as the labor supply decreases and competition increases.

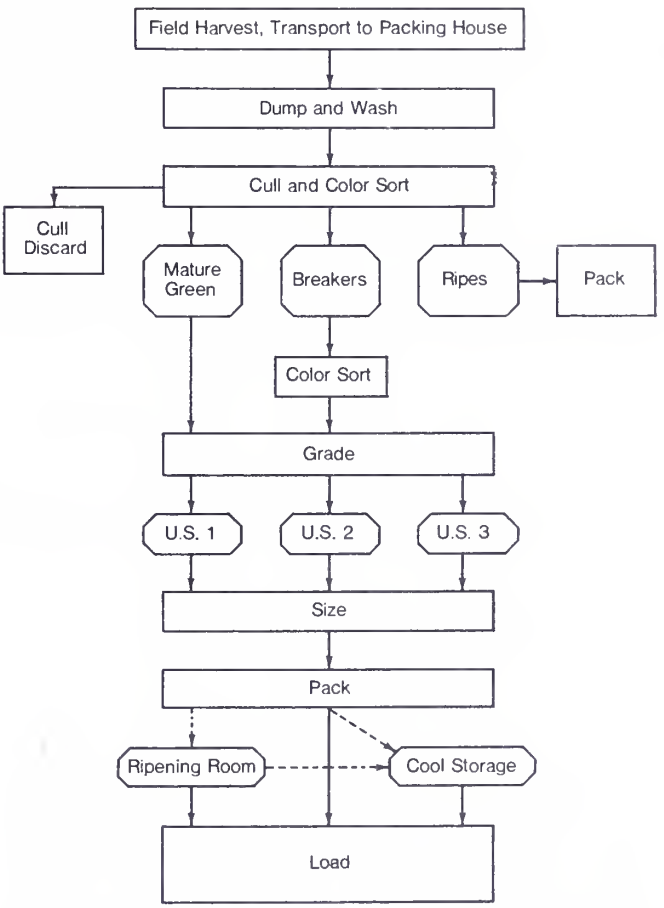
[13]Studer, H. E. and Chen, P. Mechanical Harvesting of Mature Greens Tomatoes in California. Proceedings Second Tomato Quality Workshop, Vegetable Crop Series 178, September 1976.

[14]Sims, William L., Scheuerman, Robert W. and Ririe, David. Mechanized Growing and Harvesting of Fresh Market Tomatoes. Univ. of Calif., Leaflet 2815, January 1979.

Packing plant operations generally include weighing, checking, washing, drying, waxing, sorting, grading, sizing, and packing. In most packing plants the operations are mechanized to a large extent. Figure 3 shows the basic operations at a tomato packing plant. Figure 4 shows the floor plan of a model California mature green tomato packing plant.

The packing plant is the assembly point for preparing and shipping tomatoes to market. Packing plant operators usually handle tomatoes for many growers. Some large growers have their own packing and shipping operations. It is at this stage in the marketing of tomatoes that grades and standards first assume major importance.

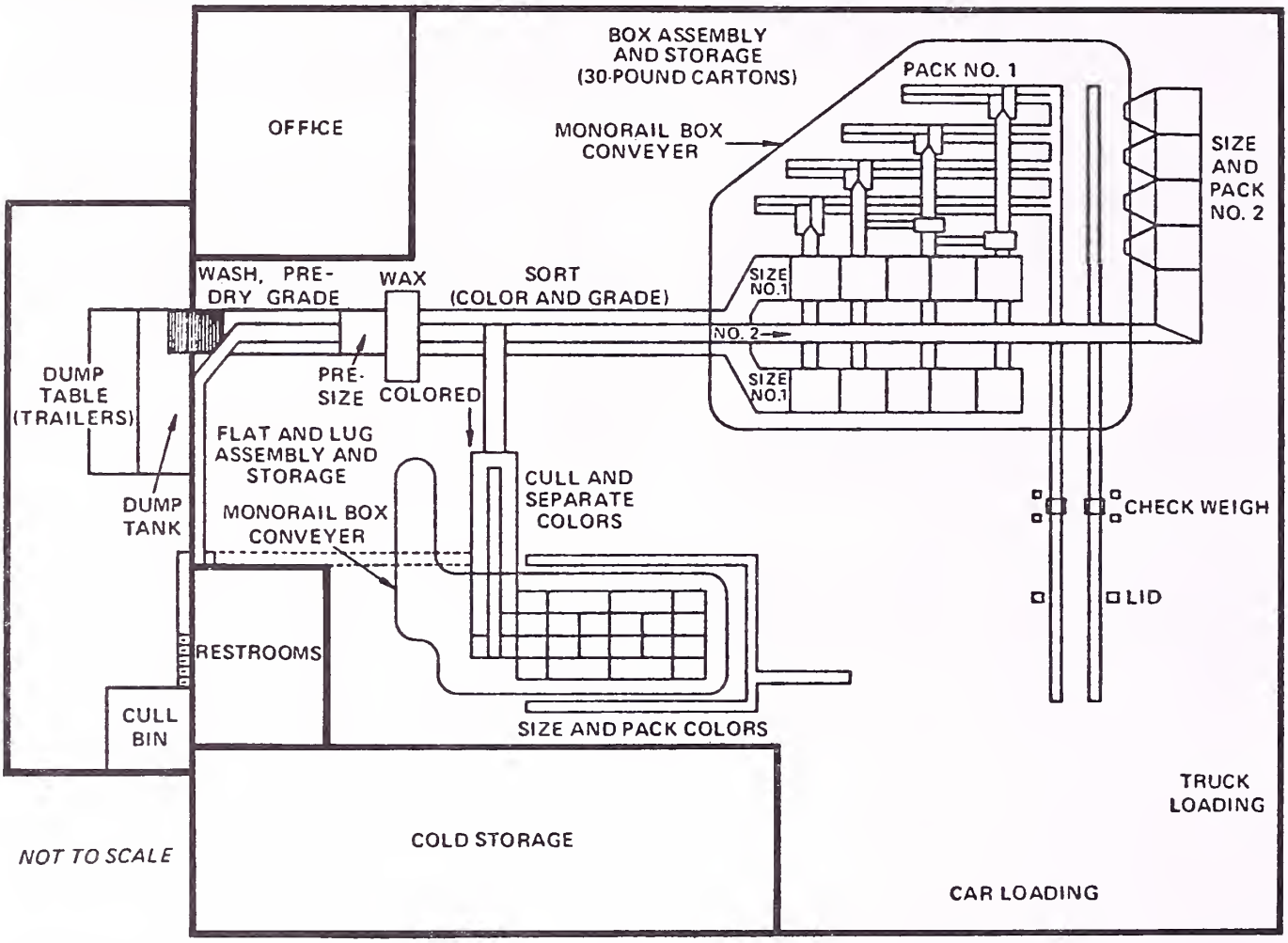
Fresh Tomato Packing Operation[1]



[1] From Fahey, James V. How Fresh Tomatoes are Marketed. U.S. Dept. Agr., Bul. 59. Oct. 1976

Figure 3.—Fresh tomato packing operation.
(See footnote 9, page 6.)

Floor Plan, Model California Mature Green Tomato Packinghouse[1]



[1]From Jesse, Edward V. Packing California Mature Green Tomatoes. U.S. Dept. of Agr. ERS, Econ. Report No. 282. Feb. 1975.

Figure 4.—Floor plan, model California mature green tomato packing house. (See footnote 12, page 9.)

At the modern packing plant, tomatoes are dumped into a tank of water and washed. They then move over a series of belts and are sorted by hand (fig. 5) for color and grade, and by machine for size. When a basically mature green lot of tomatoes is being prepared for market, breakers and riper tomatoes are sorted out and run over a separate series of belts for grading and sizing. These tomatoes are segregated into several color classifications so that the tomatoes in each container are nearly uniform in color. This aids in distributing the commodity since the riper tomatoes usually go to nearby outlets.

The final sorting is for size, whereby tomatoes pass over a series of belts with holes having specified minimum diameters. Typically, the openings have a diameter of 2-4/32 inches on the first belt and a diameter of 2-9/32 inches on the second. Tomatoes falling through the second belt would be over 2-4/32 inches in diameter but no larger than 2-9/32 inches, and would be classified as "small." There are six size designations specified under U.S. grade standards for fresh tomatoes.

At the end of the packing line, tomatoes are placed in containers (fig. 6) which usually are stamped to indicate the tomato size. A variety of containers are used, but among the more common are fiberboard cartons holding 30 pounds of jumble-packed mature greens or about 20 pounds of place-packed vine ripes.

In some producing areas, the ripening process is accelerated before shipment. Cartons of mature green tomatoes are placed in closed rooms under conditions of controlled temperature and pressure. Ethylene—an organic compound which also comes from fruit during the ripening process—is introduced into the atmosphere and hastens the degreening or ripening process. When the tomatoes begin to show color, they are shipped to market. Ethylene is used widely in Florida and to some extent in California and Mexico. Although ethylene speeds ripening, it has no effect on the flavor or nutritional value of tomatoes.[15]

The packer usually sells the tomatoes to terminal wholesale distributors or repackers. These sales are completed through field buyers who work for the receivers, or through brokers who serve as buying agents in the field for several receivers directly with the receivers. Normally, the tomatoes are sold before shipment. Occasionally, when tomatoes are ready to be shipped but are not yet sold, the shipper-packer will use a broker as a selling agent to find a buyer for the shipment during transit. The alternative to shipment would be spoilage.

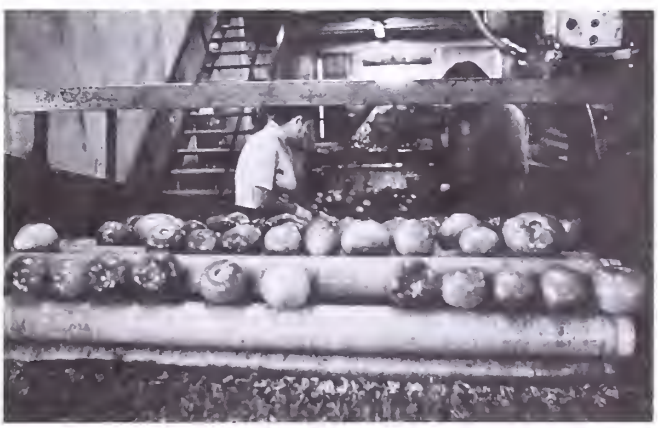


Figure 5.—Culling and grading fresh tomatoes at the packing plant.

Figure 6.—Packaging fresh tomatoes at packing plant.

The packer generally arranges for the transportation of the tomatoes, although occasionally the receivers will arrange their own transportation.[16]

Table 4 shows the estimated packing plant costs for marketing mature green tomatoes in California. The table is provided to give the reader an indication of a packing plant's cost components. These costs are based on a budget developed for central California for facilities having similar production practices. Costs can vary from packing plant to packing plant with differing volumes, operating expenses, and layout.

Table 4.—Packing plant packing and marketing costs[1]

Item	Cost per 30 lb carton
	Dollars
Labor	0.49
Machinery, equipment, buildings	.42
Pallets	.23
Cartons	.63
Miscellaneous supplies	.08
Administrative	.11
Selling	.30
Total	2.26

[1]Data from Zepp, G. A. and Simmons, R. L. Producing Fresh Tomatoes in California and Baja, California. ESCS–78, February 1980.

[15]See footnote 9, page 6.

[16]See footnote 4, page 4.

Packed tomatoes are transported to the wholesale market by refrigerated trailer (fig. 7), though rail transport is used for California, Florida, and Mexican tomatoes shipped to the larger cities in the Midwest and Northeast. Overall, about 88 percent of the fresh tomatoes move to market by truck.[17] In this study only truck movement is considered.

When trucks are used to transport the tomatoes, the shipper-packer uses a trucker broker—an agent of independent contract truckers—to locate trucks for shipment. The trucker broker's services are usually paid for by the trucker involved.[18]

Each of the four handling and shipping methods from packing plant to wholesale warehouse or repacker consists of three basic elements—loading, transporting, and unloading (fig. 8). The four handling methods include handstacking, palletized, pallet-pool, and slipsheet. In the hand-stacked method, tomato cartons are simply stacked in the trailer. In the palletized method, the cartons are shipped on wooden disposable pallets. The pallet-pool method uses resuable pallets which are returned to the shipper. Slipsheets are fiberboard sheets which serve the same purpose as disposable pallets.

The labor rates and transport charges in table 5 through table 10 have been updated from a previous report on tomato handling.[19]

Figure 7.—Trailer load of fresh tomatoes before transporting to market.

Figure 8.—Unloading cartons of fresh tomatoes at the wholesale warehouse.

Handstacked

In the hand-stack method a forklift truck at the packing plant is used to place a pallet unit into a refrigerated highway trailer. Two workers remove the cartons of fresh tomatoes and stack them in the trailer. Empty pallets are removed from the trailer with a forklift truck. The labor and equipment cost to load 900 cartons was $11.92 as shown in table 5.

Based on a rate of $1.00 per carton to transport fresh tomatoes from central Florida to Washington, D.C., the cost to transport the 900-carton trailer load was $900.

At the wholesale warehouse, after the rear doors of the trailer were opened and the dock plate positioned, warehouse personnel or the truck driver secured a stack of pallets and positioned them on the loading dock near the rear of the trailer. As a pallet was needed, the driver either hand-carried it into the trailer or moved it with a pallet jack. Assisted by a helper, the driver hand-stacked the tomato cartons on the pallet. When the pallet was loaded, it was removed from the trailer with an electric pallet jack and moved to temporary storage. From temporary storage a warehouse employee transported the full pallet to storage in the warehouse.

The labor and equipment costs to unload 900 cartons from a refrigerated highway trailer are shown in table 6. Total cost to stack the cartons on the pallets, remove from the trailer, and transport to storage was $20.69. Of this amount, labor cost to hand-stack cartons on pallets was $13.84 or 67 percent of the total unloading cost at the wholesale warehouse.

[17]See footnote 9, page 6.
[18]See footnote 4, page 4.
[19]See footnote 7, page 5.

Table 5.—Hand-stacked method: Labor and equipment time and cost to transport 900 palletized cartons of fresh tomatoes from storage and hand-stack in trailer at packing plant[1]

Element	Labor		Equipment		Total cost
	Time	Cost	Time	Cost	
	Worker-hours	*Dollars*	*Hours*	*Dollars*	*Dollars*
Transport cartons from storage into truck by forklift truck (round trip 175 feet)	0.48	2.40	0.48	0.60	3.00
Hand-stack cartons in trailer from pallets	1.56	7.80	.65[2]	.81	8.61
Remove empty pallets from trailer	.05	.25	.05	.06	.31
Total	2.09	10.45	1.18	1.47	11.92

[1]Labor and equipment costs, respectively, at $5 and $1.25 per hour.

[2]During handstacking in trailer, forklift truck occasionally remained in trailer.

Table 6.—Hand-stacked method: Labor and equipment time and cost to unload 900 hand-stacked cartons of fresh tomatoes and move to storage

Element	Labor[1]		Equipment		Total cost
	Time	Cost	Time	Cost[2]	
	Worker-hours	*Dollars*	*Hours*	*Dollars*	*Dollars*
Position dock plate and remove brace bars	0.02	0.16	—	—	0.16
Position pallets	.06	.48	—	—	.48
Hand-stack cases on pallets (50 cartons per pallet for 18 pallets) and apply warehouse location sticker on load	1.73	13.84	—	—	13.84
Remove pallet load from trailer by pallet jack (18 round trips of 125 feet each	.24	1.92	0.24	0.13	2.05
Move loaded pallet from temporary storage by forklift truck, place in storage racks, and return (18 round trips of 200 feet each)	.45	3.60	.45	.56	4.16
Total	2.50	20.00	.69	.69	20.69

[1]Based on $8 per hour.

[2]Based on $0.53 per hour for pallet jack and $1.25 per hour for forklift truck.

Cost of the hand-stacked method totaled $932.61, including hand-loading the cartons in the trailer at the packing plant ($11.92), transportation ($900), and unloading by hand at the wholesale warehouse ($20.69). Cost per carton was $1.0362 ($932.61 ÷ 900).

Palletized

With the palletized method, cartons of tomatoes were stacked on wooden pallets and loaded into the highway trailer with a forklift truck. The labor and equipment cost to load 900 cartons unitized on 18 pallets was $6.38 as shown in table 7.

A disposable 48- by 40-inch wooden pallet costing $4.75 was used in this system. Total cost of 18 disposable pallets was $85.50.

At a rate of $1.00 per carton to transport fresh tomatoes from central Florida to Washington, D.C., the cost to transport a 900-carton trailer load was $900. It was assumed that no charge was made for the extra weight of the pallets.

Table 7.—Palletized method: Labor and equipment time and cost to transport 900 palletized cartons of fresh tomatoes from storage and load in trailer at packing plant[1]

Element	Labor		Equipment		Total cost
	Time	Cost	Time	Cost	
	Worker-hours	*Dollars*	*Hours*	*Dollars*	*Dollars*
Transport cartons from storage to dock by forklift truck (round trip: 175 feet)	0.48	2.40	0.48	0.60	3.00
Move 18 loaded pallets into trailer by forklift truck	.54	2.70	.54	.68	3.38
Total	1.02	5.10	1.02	1.28	6.38

[1]Labor and equipment costs, respectively, at $5 and $1.25 per hour.

At the wholesale warehouse, pallet loads were moved from the trailer to the dock by one worker using an electric pallet jack. From the dock or temporary storage, the palletized cartons were transported with a forklift truck and positioned in the storage racks. Pallet loads on the floor were used in order selection. As bottom pallets were emptied, loads stored in racks above were lowered for order selection.

The labor and equipment costs to unload 900 palletized cartons from a refrigerated highway trailer are shown in table 8. Total cost to move the pallet loads from the trailer and transport to storage was 8.25.

Cost of the palletized method totaled $1,000.13, including loading at the packing plant ($6.38), cost of the pallet ($85.50), transportation ($900), and unloading at the wholesale warehouse ($8.25). Cost per carton was $1.1112 ($1,000.13 ÷ 900).

In 1975 only 10 percent of Florida tomato shippers used standard wooden pallets to ship cartons of tomatoes. In 1980, 75 percent of shippers were using wooden pallets.[20]

Pallet-Pool

The pallet-pool method was synthesized from the data gathered on the palletized system. A hypothetical pallet-pool arrangement is used in the pallet-pool system in place of the expendable pallet used in the palletized system.

The representative pallet in this synthesized system was a 48- by 40-inch wooden pallet. Pallet expenses were assumed to consist of a purchase price of $8.25 per pallet and repairs and expenses of $8.25 per pallet for 36 uses. This totals $16.50 per pallet. The resulting per-use cost is $0.46 ($16.50 ÷ 36). Total cost per use of the pallets for 18 units was $8.28. It was assumed, as in the palletized system, that no additional transport charge was made for the extra weight of the pallets during shipment.

The cost to return a full trailer load of pallets (500 pallets) from Washington, D.C., to Miami, Fla., was $956.00.[21] The total labor and equipment cost to load the trailer with 500 pallets and then unload in Florida was $22.26.[22] Total cost was $978.26. The cost for 18 pallets was $35.22.

Cost of the pallet-pool method totaled $958.13, including loading at the plant ($6.38), cost of the pallets ($8.28), transportation ($900), unloading at the wholesale warehouse ($8.25), and return of pallet ($35.22). Cost per carton was $1.0645 ($958.13 ÷ 900).

Slipsheet

With the slipsheet method a forklift truck having a push-pull attachment pulled the palletized unit onto the tines of the forklift truck. The unit was moved and placed in a highway trailer. Cost of 18 slipsheets (payload surface 48 inches by 40 inches) at 75 cents each for a full trailer load was $13.50.

[20]Palletization Now Commonplace. The Packer, Dec. 6, 1980.

[21]Telephone verification from a transportation company.

[22]Labor and equipment loading and unloading data based on Materials Handling Standard Time Data. Department of Defense. DOD 5010.15. 1-M, March 1967.

Labor and equipment cost to load 900 cartons of fresh tomatoes unitized on 18 slipsheets is shown in table 9. Labor and equipment costs totaled $8.31.

At a rate of $1.00 per carton to transport fresh tomatoes from central Florida to Washington, D.C., the cost to transport the 900-carton trailer load was $900.

At the wholesale warehouse, a forklift truck with a slipsheet attachment transported the slipsheet unit from the trailer and positioned it on a pallet. The loaded pallet was picked up by a conventional forklift truck and moved into storage.

Table 8.—Palletized method: Labor and equipment time and cost to unload 900 palletized cartons of fresh tomatoes and move to storage

Element	Labor[1]		Equipment		Total cost
	Time	Cost	Time	Cost[2]	
	Worker-hours	*Dollars*	*Hours*	*Dollars*	*Dollars*
Position dock plate and remove brace bars	0.02	0.16	—	—	0.16
Pickup palletized units with pallet jack, move from trailer (18 round trips of 125 feet)	.24	1.92	0.24	0.13	2.05
Straighten cartons on pallet at dock	.22	1.76	.22	.12	1.88
Move loaded pallet to storage by forklift truck, place in racks, and return (18 round trips of 200 feet)	.45	3.60	.45	.56	4.16
Total	.93	7.44	.91	.81	8.25

[1]At $8 per hour.

[2]At $0.53 per hour for electric pallet jack and $1.25 per hour for forklift truck.

Table 9.—Slipsheet method: Labor and equipment time and cost to transport 900 unitized cartons of fresh tomatoes from storage and load in trailer at packing plant.

Element	Labor		Equipment		Total cost
	Time	Cost[1]	Time	Cost[1]	
	Worker-hours	*Dollars*	*Hours*	*Dollars*	*Dollars*
Transport cartons from storage to dock by forklift truck with slipsheet attachment (round trip: 175 feet)	0.48	2.40	0.48	0.74	3.14
Move 18 loaded slipsheets into trailer with forklift truck with slipsheet attachment[2]	.79	3.95	.79	1.22	5.17
Total	1.27	6.35	1.27	1.96	8.31

[1]Labor at $5 per hour; $1.55 per hour for forklift truck with slipsheet attachment.

[2]Slipsheet loading data from ARS-NE-47, A Cost Comparision of Alternative Systems for Shipping Citrus in Refrigerated Highway Trailer Vans. 1974.

Labor and equipment costs to unload 900 cartons, unitized on slipsheets from a refrigerated highway trailer, are shown in table 10. Total cost to move the slipsheet loads from the trailer and move to storage was $14.50.

Cost of the slipsheet method totaled $936.31, including loading at the packing plant ($8.31), cost of the slipsheets ($13.50), transportation ($900), and unloading at the wholesale warehouse ($14.50). Cost per carton was $1.0403 ($936.31 ÷ 900).

Many mature green tomatoes are shipped to repackers in terminal markets. These repackers specialize in ripening and resorting tomatoes for color uniformity. Some retail groups have their own ripening facilities. Upon arrival at the repacker the tomatoes are not all ripe enough to package; thus, the repacker sorts them, packages the ripe tomatoes for retail sale, and holds the rest for ripening. This process must be repeated, so some tomatoes are rehandled many times before being packaged into customer units.

The consumer units are film-overwrapped in three- or four-tomato plastic trays (fig. 9). The trays are hand-packed in 10-tray master cartons, and these are palletized and transferred by forklift to trucks for delivery to a distribution warehouse.[23]

Repacking cost per 1,000 pounds ranges from $46.70 for a repacker with 1.5-million-pound capacity to $36.60 for a repacker with 10-million-pound capacity.[24] These costs include labor and equipment requirements to sort, pack, and handle within the repacking facility. Detailed cost information is not given for the repacking operation because facility layout and volume handled among repackers vary greatly and were not studied in detail as a part of the total systems analysis.

Table 10.—Slipsheet method: Labor and equipment time and cost to unload 900 cartons of fresh tomatoes on slipsheets and move to storage

Element	Labor[1]		Equipment		Total cost
	Time	Cost	Time	Cost	
	Worker-hours	*Dollars*	*Hours*	*Dollars*	*Dollars*
Position dock plate	0.02	0.16	—	—	0.16
Manually position 18 pallets on dock	.12	.96	—	—	.96
Transport 18 slipsheet loads from trailer to dock and place on pallets using a forklift truck with slipsheet attachment (18 round trips of 125 feet)	.79	6.32	0.79	0.99[2]	7.31
Straighten cartons on pallet at dock	.20	1.60	.20	31[2]	1.91
Move loaded pallets to storage by forklift truck, place in storage racks, and return (18 round trips of 200 feet)	.45	3.60	.45	.56[3]	4.16
Total	1.58	12.64	1.44	1.86	14.50

[1]At $8 per hour.

[2]$1.55 per hour for forklift truck with slipsheet attachment.
[3]$1.25 per hour for forklift truck.

[23]See footnote 8, page 6 .

[24]Cost data are updated to 1981 using an annual inflation factor of six percent from Myers, Charles H. Tomato Repacking Methods and Equipment. U.S. Dept. Agr., ARS, MRR-597. October 1963.

Figure 9.—Consumer-size packs in a master carton.

In recent years trends indicate the decreasing importance of specialized tomato repacking.[25] Many tomato repackers are diversifying into other fruits and vegetables, such as citrus, lettuce, cantaloupes, and apples. A major repacker in a large eastern city has stated that repacking is becoming a smaller percentage of his tomato business. Labor, film, and tray costs are some of the reasons that repacking has declined.[26]

Tomatoes that are not shipped to repackers go to wholesale warehouses where they are assembled with other produce into mixed loads and transported to retail stores.

Since handling tomatoes into warehouse storage is included with transportation, the wholesale warehouse function includes handling and delivery of fresh tomatoes as part of a mixed load (fig. 10) from the warehouse storage area to temporary storage at the retail store. Labor and equipment costs were developed for the three major methods for movement of the product from wholesaler to retailer. The three methods are: (1) hand-stacked delivery, (2) palletized delivery, and (3) mobile cart delivery.

Handstacked Delivery

In this method of delivery, the cartons of tomatoes and other cases of produce were selected and placed on four-wheel selector trucks pulled through the warehouse by an electric tugger. One worker on the dock took cases and cartons of the mixed load from the selector trucks and stacked them in the trailer.

After the trailer was fully loaded, it was usually moved to a lot and parked. During delivery at the retail store, a gravity roller conveyor was used to unload the trailer. The labor requirements and costs to select, restock, load, deliver, and unload a trailer with 1,000 cases and cartons (of which 75 are cartons of fresh tomatoes) are shown in table 11. Labor costs per 75 cartons of tomatoes were $10.56 or $0.1406 per carton.

Table 12 shows the equipment time and costs for the handstacked delivery system operations. Equipment cost per tomato load was 28 cents or $0.0036 per carton.

Figure 10.—Order assembly of tomatoes and other products at wholesale warehouse.

[25]Straight Tomato Repack Era Fast Coming to End. The Packer, June 1976.

[26]Eastern Repackers Using Summer Calif. Varieties. Repacking Slowed by Trend to Bulk, The Packer. June 1981.

Table 11.—Labor requirements and costs for selecting, replenishing stock loading, delivering, and unloading handstacked cartons of fresh tomatoes from warehouse to retail store as part of a mixed-produce trailer load

Element	Per trailer load[2]	Per tomato load	Cost[3]	
			Per tomato load	Per tomato carton
	Worker-hours		*Dollars*	
Select cases of produce and stack on selector trucks pulled by electric tugger	5.08	0.38	3.04	0.0405
Replenish stock	.73	.05	.40	.0053
Load cases into trailer	2.58	.19	1.52	.0202
Deliver to store and return	3.20	.24	1.92	.0256
Unload at store	6.08	.46	3.68	.0490
Total	17.67	1.32	10.56	.1406

[1]Trailer load consists of 1,000 cases and cartons of produce, of which 75 are tomato cartons.

[2]Shaffer, P. F. and D. M. Steckler, Comparative Methods of Handling Produce From Warehouse Slots to Holding Areas in Retail Store. ARS-NE-49, November 1974.

[3]At $8 per hour.

Table 12.—Equipment time and costs for selecting, loading, and unloading handstacked cartons of fresh tomatoes from warehouse to retail store as part of a mixed-produce trailer load

Element	Per tomato load	Cost per tomato load[1]	Cost per carton[2]
	Hours	*Dollars*	*Dollars*
Use of electric tugger	0.38	0.19	0.0025
Use of four-wheel selector trucks	1.14	.01	.0001
Use of roller conveyor for unloading	.45	.08	.0010
Total	1.97	.28	.0036

[1]At $0.49, $0.005, and $0.18 per hour for the first, second, and third cost data, respectively.

[2]For 75 cartons.

The transport trailer made an 80-mile round trip during the delivery with a fixed cost of $3.12 per hour for tractor and trailer for 8 hours (8 × $3.12 = $24.96), total fixed cost was $24.96. Operating cost was $1.57 per mile. Total ownership and operating cost for the delivery trip was $150.56 or $0.1506 per carton.

The total labor, equipment, and transport cost to deliver handstacked fresh tomatoes to the retail store from the wholesale warehouse was $0.2948 per carton (labor = $0.1406, equipment = $0.0036, transportation = $0.1506).

Palletized Delivery

With palletized delivery, cartons of fresh tomatoes and other cases of produce are selected and stacked on pallets with use of electric pallet jacks to move product through the selection area, to the loading dock, and into the trailer.

At the retail stores the pallets are unloaded by one worker using a pallet jack to unload and move product to temporary storage. The labor requirements and costs to select, restock, load, deliver, and unload a trailer with 1,000 cases and cartons, of which 75 are cartons of tomatoes, are shown in table 13. Labor costs per 75 cartons of tomatoes were $7.28 or $0.0969 per carton.

Table 14 shows the equipment time and costs for the palletized delivery system operations. Equipment cost per tomato load was 34 cents or $0.0044 per carton.

Table 13.—Labor requirements and costs for selecting, replenishing stock, loading, delivering, and unloading palletized cartons of fresh tomatoes from warehouse to retail store as part of a mixed-produce trailer load[1]

Element	Per trailer load[2]	Per tomato load	Cost[3]	
			Per tomato load	Per tomato carton
	Worker-hours		*Dollars*	
Select cartons of product and stack on pallets	4.87	0.36	2.88	0.0384
Replenish Stock	.73	.05	.40	.0053
Load palletized units into trailer	.62	.05	.40	.0053
Deliver to store and return	3.39	.25	2.00	.0266
Unload at store	2.65	.20	1.60	.0213
Total	12.26	.91	7.28	.0969

[1]Trailer load consists of 1,000 cases and cartons of produce, of which 75 are tomato cartons.

[2]Shaffer, P. F. and D. M. Steckler, Comparative Methods of Handling Produce From Warehouse Slots to Holding Areas in Retail Store. ARS-NE-49, November 1974.

[3]At $8 per hour.

Table 14.—Equipment time and costs for selecting, loading, and unloading palletized cartons of fresh tomatoes from warehouse to retail store as part of a mixed-produce trailer load

Element	Per tomato load	Cost per tomato load[1]	Cost per carton[2]
	Hours	*Dollars*	
Use of pallet jack	0.61	0.32	0.0042
Use of pallets	11.53	.02	.0002
Total	12.14	.34	.0044

[1]At $0.53, $0.002 per hour for pallet jacks and pallets, respectively.

[2]For 75 cartons.

The transport trailer made an 80-mile round trip during the delivery. With a fixed cost of $3.12 per hour for tractor and trailer for 7.74 hours (7.74 × $3.12 = $24.15), total fixed cost was $24.15. Operating cost was $1.57 per mile. Total ownership and operating cost for the delivery trip was $149.75 or $0.1497 per carton.

The total labor, equipment, and transport cost to deliver fresh tomatoes on pallets to the retail store from the wholesale warehouse was $0.2510 per carton (labor = $0.0969, equipment = $0.0044, transportation = $0.1497).

Mobile Cart Delivery

In this method of delivery, the cartons of fresh tomatoes and other cases of produce were selected and loaded onto mobile carts that were then transported to the loading dock and loaded onto the trailer. All movement was accomplished with the use of an electric tugger.

At the retail store the carts were manually unloaded across a truck bed-level dock. The carts were then transported to temporary storage in the store.

The labor time and cost to select, restock, load, deliver, and unload a trailer with 1,000 cases and cartons, of which 75 are cartons of fresh tomatoes, are shown in table 15. Labor cost per 75 cartons of tomatoes was $7.84 or $0.1043 per carton.

Table 16 shows the equipment time and cost for the mobile cart delivery method operation. Equipment cost per tomato load was 59 cents or $0.0078 per carton.

The transport trailer made an 80-mile round trip during the delivery. With a fixed cost of $3.12 per hour for tractor and trailer for 7.67 hours (7.67 = $3.12 = $23.93), total fixed cost was $23.93. Operating cost was $1.57 per mile. Total ownership and operating cost for the delivery trip was $149.53 or $0.1495 per carton.

The total labor, equipment, and transport cost to deliver fresh tomatoes to the retail store from the wholesale warehouse was $0.2616 per carton (labor = $0.1043, equipment = $0.0078, transportation = $0.1495).

The handling of produce, including fresh tomatoes, from backroom storage to display case is usually performed using a two-wheel handtruck, although shopping carts, four-wheel carts, and manual pallet transporters also are used. Three or four cases or cartons of tomatoes are stacked on the cart or handtruck in the storage area and transported to the display area as needed. After the tomatoes are removed from the cartons and placed in the display case, the empty cartons and cases are broken down and transported to the disposal area in the rear of the store.

Table 17 shows the labor and equipment time and costs to perform these operations. Total labor and equipment cost was $0.23 per carton.

Table 15.—Labor time and costs for selecting, replenishing stock, loading, delivering, and unloading cartons of fresh tomatoes stacked on mobile carts from warehouse to retail store as part of a mixed-produce trailer load[1]

Element	Per trailer load[2]	Per tomato load	Cost[3]	
			Per tomato load	Per tomato carton
	Worker-hours		*Dollars*	
Select cartons of product and stack on mobile carts	5.88	0.44	3.52	0.0469
Replenish stock	.73	.05	.40	.0053
Load mobile carts into trailer	1.05	.08	.64	.0085
Deliver to store and return	3.79	.28	2.24	.0298
Unload at store	1.76	.13	1.04	.0138
Total	13.21	.98	7.84	.1043

[1]Trailer load consists of 1,000 cases and cartons of product, of which 75 are tomato cartons.

[2]Shaffer, P. F. and D. M. Steckler, Comparative Methods of Handling Produce from Warehouse Slots to Holding Area in Retail Stores, ARS-NE-49, November 1974.

[3]At $8 per hour.

Table 16.—Equipment time and costs for selecting, loading, and unloading cartons of fresh tomatoes stacked on mobile carts from warehouse to retail store as part of a mixed-produce trailer load

Element	Per tomato load	Cost per tomato load[1]	Cost per carton[2]
	Hours	*Dollars*	
Use of electric tugger	0.44	0.22	0.0029
Use of mobile carts	12.48	.37	.0049
Total	12.92	.59	.0078

[1]Based on $0.49, $0.03 per hour for the first and second cost data, respectively.

[2]For 75 cartons.

Packaging

Generally, three different types of packing are used in the movement of fresh tomatoes from the packing plant to the retail store. These containers and their approximate costs are: 30-pound fiberboard shipping containers $0.899 or plastic trays and overwrap $0.034 (3 or 4 tomato consumer packs) and the master container for the trays $0.146.[27] Since the average consumer pack weighs .89 pounds, 30 pounds of tomatoes yields 33.7 consumer packs.

The packaging cost for 30 pounds of tomatoes in consumer packs would be approximately $1.63 ($0.034 × 33.7 = $1.14 plus $0.492).

Damage and Decay Losses

Very little information on losses in harvesting and packing has been published. In harvesting, the quality of the fruit is probably as good as can be produced. The volume of fruit picked allows little time for quality decisions by the picker. Fruits with defects such as catface, deformity, or cracks, or fruits with blossom-end rot, gray wall, or decay can comprise 20 percent or more of the harvest. Fingernail cuts, stem punctures, scarring, and scuffing originate at harvest. The dumping of harvested fruit into boxes or bulk bins, the weight of fruit on fruit, and movement of the tomatoes during transport from field to packing plant can cause both external and internal damage. The damage shows up as scuffing or sand scarring of the skin, cracking, or internal bruising. External blemishes not only detract from the appearing but increase the chance of decay. Internal bruises are not always visible externally, but can cause fermentation and off-flavors in the fruit. Internal damage can also manifest itself later in the ripened fruit as soft, water-soaked, disoriented, and sometimes discolored tissue.[28]

At the packing plant the tomatoes are graded and checked for decay, sunburn, cuts, shoulder scars, sunken discolored scars, growth cracks, bruises, broken skin, puffines, catface, insect damage, hail injury, chilling injury, deformity, correct size class, and maturity.

Table 17.—Labor and equipment costs to handle fresh tomatoes from storage to display case using a two-wheeled handtruck[1]

Element	Labor[2]		Equipment[3]		Cost per carton[4]
	Time	Cost	Time	Cost	
	Worker-hours	*Dollars*	*Hours*	*Dollars*	*Dollars*
Load two-wheel handtruck[3]	0.017	0.136	0.017	[5]	0.034
Transport load from storage area to display case (105 feet one way)	.009	.072	.009	[5]	.018
Place tomatoes in display case	.062[6]	.496	.062	[5]	.124
Break down empty cartons, move cartons to disposal area, and return to storage area (105 feet one way)	.029	.232	.029	[5]	.058
Total	.117	.936	.117	.0005	.234

[1]Average round trip of 210 feet. [2]At $8 per hour [3]At $0.0005 per hour. [4]Four cartons per load. [5]Negligible.

[6]Time for placing loose tomatoes from carton into the display case. Time for placing consumer packs from carton into the display case would be less.

[27]See footnote 8, page 6. Inflation factor of 6 percent for 2 years.

[28]See footnote 8, page 6.

There are four USDA grades of fresh tomatoes (U.S. No. 1, U.S. No. 2, U.S. No. 3, and U.S. Combination).[29] Usually, tomatoes are graded so that a given lot will contain a specified percentage of the U.S. No. 1 grade.[30] U.S. No. 1 allow 15 percent defects at destination (repacker).

Cullage rate at the packing plant depends on the condition of the fruit and the selected grade to be packed. The cost of packing increases with cullage rate. As cullage increases, producer return decreases.

Quality deterioration of green tomatoes begins with injury during harvest and continues during its highly mechanized handling in the packing plant. Injury occurs internally and externally. Stem scars, blossom scars, and skin cuts are entry ports for decay-producing organisms as well as other foreign material.

A study done in California indicated that, of the shipping cartons examined at shipping point, 55 percent of the fruit had some type of mechanical injury.[31]

Another study,[32] done in California, examined sources of damage to fresh tomatoes at harvesting, transport to the packing plant, and at the packing plant. Four systems, or combinations of functions, were studied. Samples of the fruit from the four systems were taken after the tomatoes were loaded in the field in either bins or bulk trailers, after transport to the packing plant, after being dumped from the primary container at the packing plant, and after being packed in 30-pound cartons.

In all four systems the tomatoes were hand-harvested into plastic baskets and either transferred into plywood bins (two systems) or bulk trailers (two systems). The distance varied from 4 to 60 miles for transport from field to packing plant. At the packing plant the fruit was dumped onto conveyors (three systems) or flumed (one system).

Generally, the amount of damage increases with increased handling. Also, fruit damage can vary according to the configuration of the packing line. Kasmire and Studer concluded by stating, "A much more refined subjective measure or a means of objectively measuring fruit damage is needed to improve the effectiveness of this type of study."

Bruising can occur during transit from packing plant to terminal market. During transit the pressure of the fruit resting on each other in the bulk-type fiberboard boxes, plus the movement of the load, can cause damage to the fruit.

There is little information on tomato losses at destination. What has been published, for the most part, is outdated.

At the repacker additional handling causes damage to the fruit. Losses in ripening and repacking rooms were estimated to be 10-12 percent in 1965.[33] Friedman reported a 7-percent tomato retailing loss by a large food chain in 1956.[34]

One of the most up-to-date studies[35] on tomato (loose and prepackaged) losses was conducted over a 3-year period starting in 1974. The study was conducted in eight greater New York supermarkets. During this test period about 159,000 prepackaged tomatoes and 120,900 loose tomatoes were displayed or sold in the retail stores.

Table 18 shows some of the study results. Losses at the retail level were 6.3 and 6.7 percent in prepackaged and loose fruits, respectively, and in consumer samples 7.9 and 4.7 percent in prepackaged and loose, respectively.

The study concluded by stating the data revealed disease is the greatest contributor to losses of fresh tomatoes on the market. Much of the loss found in the study was caused by pathogens that are innocuous in the field. These pathogens inhabit packinghouses, transit vehicles, ripening rooms, and wholesale and retail storages. Tomatoes must be physically injured to be invaded by many of these organisms. Decay and physical damage found in the study indicate fresh tomatoes are frequently mishandled in marketing channels. To minimize physical

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[29]Peterson, E. L. United States Standards for Grades of Fresh Tomatoes (38 F.R. 23931). USDA Agr. Mkt. Serv. 1976.

[30]See footnote 9, page 6.

[31]MacLeod, R. F., A. A. Kader, and L. L. Morris. Damage to Fresh Tomatoes Can Be Reduced. Calif. Agr. 30 (12): 10-12, 1976.

[32]Kasmire, R. F. and Studer, H. E. Tomato Damage in Commercial Harvesting and Packing Operations. Fresh Tomato Research 1974. Vegetable Crop Series 171. University of California, March 1975.

[33]United States Department of Agriculture. Losses in agriculture. U.S. Dept. Agr., Agr. Hndbk. 29. 1965.

[34]Friedman, B. A. Market Diseases of Fresh Fruits and Vegetables. Econ. Bot. 14:145-156. 1960.

[35]Ceponis, M. J. and Butterfield, J. E. Losses in Fresh Tomatoes at the Retail and Consumer Levels in the Greater New York Area. J. Amer. Soc. Hort. Sci. 104(6): 751-754. 1979.

Table 18.—Fresh tomato waste in greater New York retail stores and in consumer samples, 1974-77[1]

Location of loss and type of packaging	Causes of loss			
	Diseases	Physical injuries	Physiological disorders	Total
	Percent by weight			
Retail				
Prepackaged . .	4.2	1.5	0.6	6.3
Loose	3.8	2.0	.9	6.7
Consumer				
Prepackaged . .	6.5	1.1	.3	7.9
Loose	3.8	.7	.2	4.7

[1] From Ceponis, M.J. and Butterfield, J.E. Losses in Fresh Tomatoes at the Retail and Consumer Levels in the Greater New York Area. J. Amer. Soc. Hort. Sci. 104(6): 751-754, 1979.

injuries and related losses that ensue, the need for careful handling of tomato fruits at all stages of marketing must be emphasized.

Losses occur at all levels of the tomato marketing system. On the basis of USDA statistics, 118 pounds of tomatoes would have to be harvested for every 100 pounds of tomatoes sold at the retail store.[36]

One solution to reducing losses caused by disease may be provided from previous research.[37] The authors stated, "Provided the fruits were originally sound and of good quality, diseases of tomatoes. . .on the market can be greatly reduced by proper handling to avoid mechanical injury, by prompt cooling to the desired temperature in transit, and by proper handling and ripening at the market. . . . Very few fungi or bacteria are able to penatrate the uninjured skin of the fruit, and yet there are serious losses each year resulting from infections by a number of these organisms. Minute injuries such as broken glandular hairs, skin checks, and sand scarring are common avenues for infection on apparently sound fruits.

"In addition, visible blemishes and injuries such as growth cracks, faulty blossom scars, shoulder scars, and mechanical injuries frequently permit infection and decay. The majority of rots, however, are the result of infection by fungi and bacteria present on the fruits when harvested."

[36]See footnote 4, page 4.

[37]McColloch, Cook and Wright. Market Diseases of Tomatoes, Peppers and Eggplants. USDA AH 28. February 1968.

Transport charges are the single largest cost item in the harvesting and movement of fresh tomatoes from growing area to retail market. Loading and unloading functions and the addition of shipping platforms (pallets and slipsheets) add to the transport cost.

During manual harvesting of fresh tomatoes the method that used 800-pound-capacity bins had lower labor, equipment, and material cost per ton than methods that used 30- and 50-pound-capacity field containers. If tomato damage is not a factor with the larger bins, this would be the most cost efficient system to employ. Direct cost per ton for this system was $24.08 or $0.012 per pound. If bins are employed, the packing plant must have the unloading equipment to transport the bins from the field trucks into the packing plant.

Mechanical harvesting of fresh tomatoes is still in the experimental stages. Because of lack of labor availability and other economic factors, such as competition, the commercial application of mechanical harvesting is inevitable.

In the packing plant phase of the market system, costs can vary based on efficiency of plant layout, employees' skill, and volume of tomatoes handled. Generally, packing plant cost for a 30-pound carton of fresh tomatoes was approximately $2.26 per carton, or $0.0753 per pound. This cost includes both direct and indirect costs.

Of the four transportation methods examined, the hand-stacked method was the lowest cost system studied ($1.0362 per carton). When loading dock space is at a premium at destination, the unitized methods (pallet and slipsheet), even though their cost per carton ($1.1112 and $1.0403, respectively) was higher, may be the best methods to employ. Unloading is faster which results in faster trailer turnaround and reduced time at the dock. Because of the many problems such as pallet return associated with the pallet-pool method ($1.0645 per carton), this method is not viable at this time.

Tomato repacking is declining as a total percent of the fresh market tomatoes sold. Some of the causes for this decline are trends in the industry and higher labor and material costs. Generally, the higher the volume handled the lower the repacking costs per pound.

If the tomatoes go to a repacker there is an added cost for this operation. These costs ranged, depending on the annual volume handled, from $36.60 to $46.70 per 1,000 pounds or $0.0366 to $0.0467 per pound. Also, loading, transportation, and unloading costs are added from the repacker to the wholesale warehouse.

When tomatoes arrive at the wholesale warehouse they are stored until needed for shipment to the retail store. Three methods for movement of fresh tomatoes from the wholesale warehouse to the retail store were examined. Palletized delivery had the lowest labor, equipment, and transportation cost per carton ($0.2510). Costs per carton for handstacked delivery and mobile cart delivery were $0.2948 and $0.2616, respectively.

Costs to move fresh tomatoes from the storage room to the display case at the retail store were $0.23 per carton.

Packaging cost is an important item in marketing any agricultural product. Cost for the 30-pound fiberboard container is approaching $1.00 per carton, while the cost of the plastic trays and overwrap is almost $0.04 and that of the master container for these three and four tomato consumer packs is almost $0.15. Packaging cost for 30 pounds of tomatoes in consumer packs would be approximately $1.63.

Information on damage and decay losses for fresh tomatoes, as well as other agricultural products, is usually not available for most phases of the marketing system. Although some studies have been made, more data are needed. It is apparent, however, that more physical handling a perishable product receives, the more likelihood that damage will occur. Careful handling can reduce damage at all stages of the marketing channel.

With the current marketing system the tomato received by the consumer is good, but it could be better. Additional research is needed to find more efficient and less costly means of marketing tomatoes and to find ways to reduce damage and decay losses.

Table 19.—Hourly ownership and operating costs for equipment used in handling systems for fresh-market tomatoes

Type of Equipment	Annual ownership costs									Total ownership and operation cost per	
	Initial cost per unit	Years of depreciation[1]	Depreciation	Interest[2]	Insurance and taxes at 4%	Total	Power[3]	Maintenance[4]	Total	Year	Hour
	Dollars	*Number*					*Dollars*				
Forklift truck 4,000-lb capacity	11,000	10	1,100.00	495.00	440.00	2,035.00	296.00	165.00	461.00	2,496.00	1.248[6]
Pallet jack	3,800	10	380.00	171.00	152.00	703.00	296.00	57.00	353.00	1,056.00	.528[6]
Forklift truck with push-pull attachment	14,000	10	1,400.00	630.00	560.00	2,590.00	296.00	210.00	506.00	3,096.00	1.548[6]
Four-wheel selector truck	50	12	4.17	2.25	2.00	8.42	—	.75	.75	9.17	.005[6]
Pallet (48 X 40 GMAC)	8.25	3	2.75	.37	.33	3.45	—	1.40[5]	1.40	4.85	.002[6]
Electric tugger	4,000	7	571.43	180.00	160.00	911.43	—	60.00	60.00	971.43	.486[6]
Mobile cart	200	5	40.00	9.00	8.00	57.00	—	3.00	3.00	60.00	.030
Tractor	25,000	6	4,166.67	1,125.00	1,000.00	6.291.67	—	—	1.57/mile	6,291.67	2.029[7]
Refrigerated trailer	14,000	8	1,750.00	630.00	560.00	2,940.00	—	—	—	2,940.00	1.089[7]
Roller Conveyor	600	5	120.00	27.00	24.00	171.00	—	9.00	9.00	180.00	.180[8]
Two-wheel handtruck	50	12	4.17	2.25	2.00	8.42	—	.75	.75	9.17	.005[8]

[1] Straight line depreciation. [2] Computed interest is 9 percent for half the equipment life prorated over the full life.

[3] Power cost for battery charging of electric-powered vehicles computed from manufacturers' specifications. [4] Maintenance of 1.5 percent of cost.

[5] Estimated. [6] Based on 2,000 hours per year. [7] 3,100 hours for tractors and 2,700 hours for trailers. [8] 1,000 hours of use per year.

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